

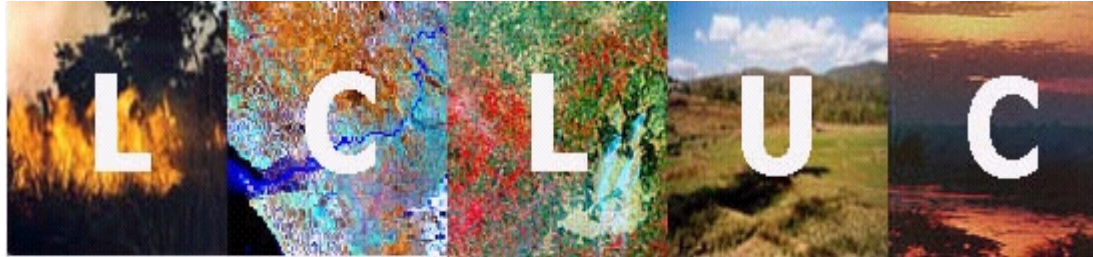
# **NASA Land Cover and Land Use Change (LCLUC) Program**

# **Land Cover and Land Use Change and Global Change**

- **LCLUC is the most immediate and visible form of environmental change**
- **Little has been developed in terms of the underpinning science of LCLUC, understanding the processes, impacts of LCLUC and predicting LCLUC**
- **LCLUC will continue to be important for the foreseeable future, driven by the demand for land, world population growth, the need for an increased food supply and wood products and socio economic forces**
- **LCLUC plays an important role in the global carbon cycle**
- **LCLUC contributes to climate change e.g. source of greenhouse gases**
- **LC and LU are impacted by climate change - effect of interannual, decadal and centennial climate variability and trends on land cover and land use**
- **LC and LUC can have an impact on the provision of ecological goods and services e.g. food supply, water quality, biodiversity**



# NASA Land Cover and Land Use Change



- LCLUC is an interdisciplinary scientific theme within NASA's Earth Science Enterprise (ESE). The ultimate vision of this program is to develop ***the capability to perform repeated global inventories of land-use and land-cover from space, to develop the scientific understanding and models necessary to simulate the processes taking place, and evaluate the consequences of observed and predicted changes.*** The underlying philosophy of the ESE LCLUC Program is to further the understanding of the consequences of land-use and land-cover changes for continued provision of ecological goods and services.
- <http://lcluc.gecp.virginia.edu/>

# **Rationale for the NASA Land Cover Land Use Research Program**

- Land use change contributes to climate change
- Land use change is impacted by climate change and variability
- The process of land use change is driven by physical and socioeconomic drivers
- Satellite data can be used to quantify the pattern of land cover change and contribute to an understanding of the processes

# **Selected Policy Dimensions of Land Cover and Land Use Change**

Scientific underpinning to provide policy relevant information on :

- Carbon Sources and Land Use
- Carbon Sinks and Land Use
- Habitat Loss and Fragmentation
- Food Production and Distribution
- Management of Ecosystems for Goods and Services
  - water supply and quality
- Human Health

# **Example of LCLUC Policy Relevance: Carbon Sources, Sinks and Land Use**

- **Carbon Sources**
  - Land-use change in tropics roughly 20-30% of total anthropogenic flux to atmosphere
  - Non-Annex I countries have no formal commitments under Kyoto Protocol
  - What are appropriate incentives to reduce this flux without adverse impacts on local livelihoods?
- **Carbon Sinks**
  - Roughly 1-2 GtC per year are taken up by terrestrial ecosystems in north temperate/boreal latitudes
  - Are there ways to maintain or enhance this sink?
  - Implications of Kyoto for land use - IPCC special report on Land Use
  - Can carbon offset or trading programs result in real gains and revenue streams for other policy goals, e.g. biodiversity conservation?

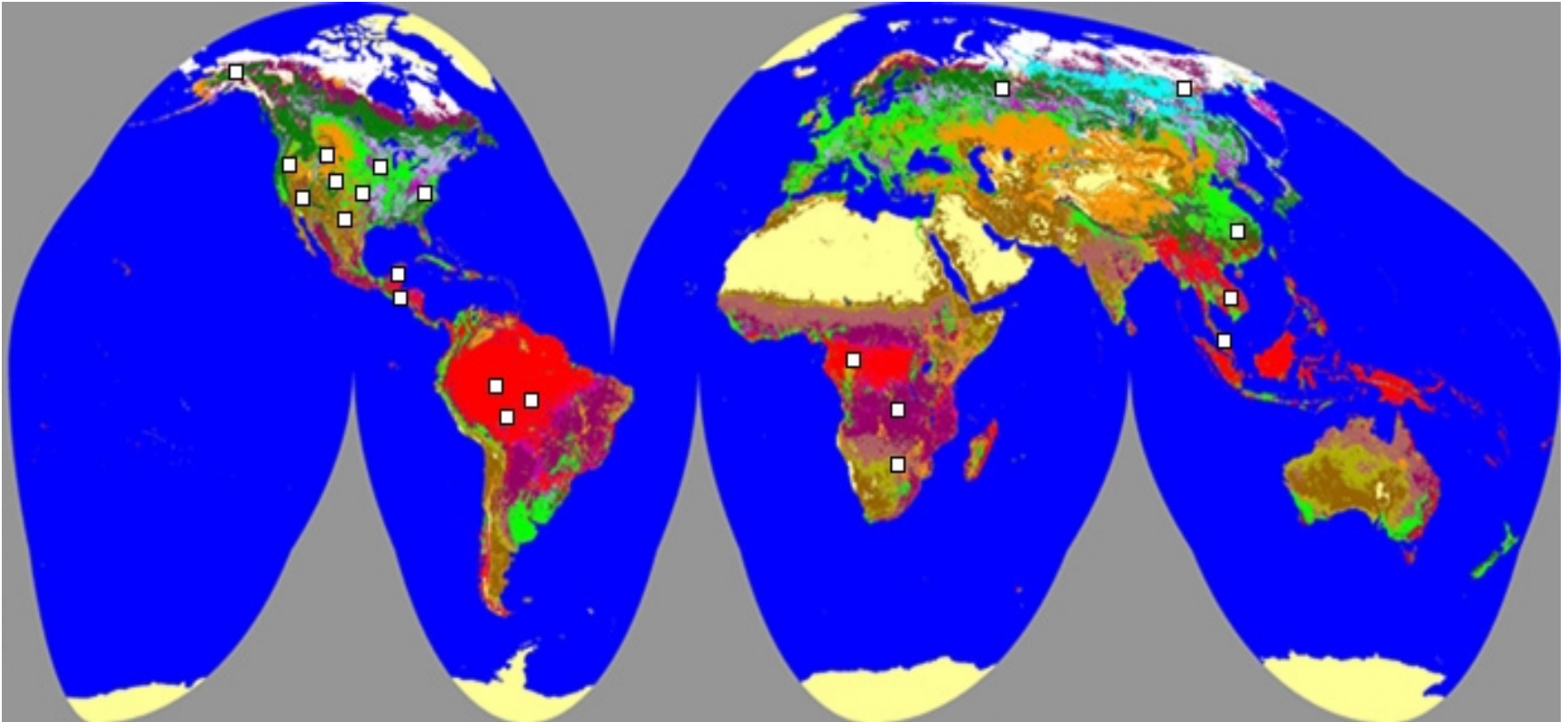


# NASA LCLUC Program Components

- **Forcing Factors**
  - **Climate and Ecological Drivers**
  - **Socioeconomic Drivers**
- **Responses and Consequences**
  - **Land cover conversion, abandonment**
  - **Land use intensification**
  - **Land degradation**
  - **Landscape fragmentation**
- **Modeling and Implications**
  - **LCLUC modeling**
  - **coupled modeling of biogeochemistry e.g. carbon**
  - **modeling land atmosphere interactions**
- **Technique Development**
  - **Remote Sensing R and D**
  - **In-situ data collection - surveys / validation / process studies**
  - **Data Management**
- **Satellite Observations**
  - **Long -term measurements**
    - Landsat series
    - AVHRR.>MODIS>NPP>VIIRS
  - **Experimental missions**
    - EO-1 - hyperspectral
    - Vegetation Canopy Lidar (VCL)
    - Vegetation Recovery Mission
  - **Commercial Data Buy**
    - Ikonos - hyperspatial
    - Geocorrected Global Landsat Database



# NASA LCLUC case study locations

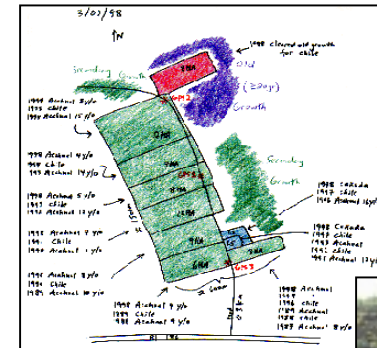


**\* 22 research projects, combining satellite remote sensing, physical and social science**

# Land-Cover Land-Use Change in the Southern Yucatán Peninsular Region, Mexico

PI B. Turner, Clark University

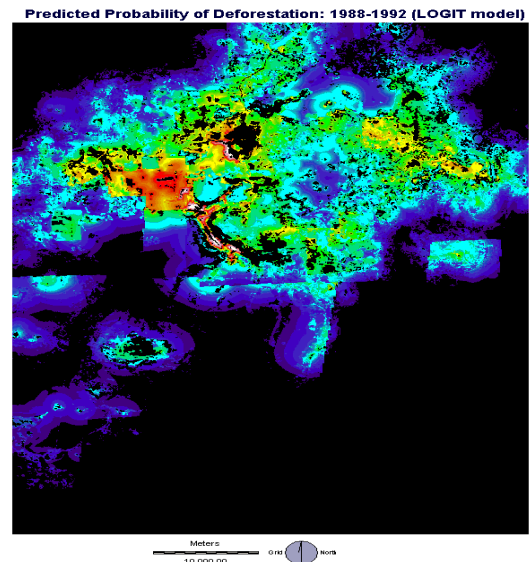
- Understanding changes in deforestation and agriculture since the 1960's, to develop models capable of projecting land use and cover changes.
- Household survey (200 households), remote sensing, econometric and empirical modeling.
- Region dominated by forest clearing for agriculture, logging, tourism
- Clearing driven by external markets for commercial for crops and subsistence needs
- Analysis of agrarian decision making, resource profiles, land tenure, ecological conditions
- Modeled prediction of deforestation completed, integrated model under development to provide scenario assessment for policy
- Domestic agricultural reform
- Government subsidies (government credits linked to commercial cropping)
- Land tenure



Sketch map, land use history >20 yrs



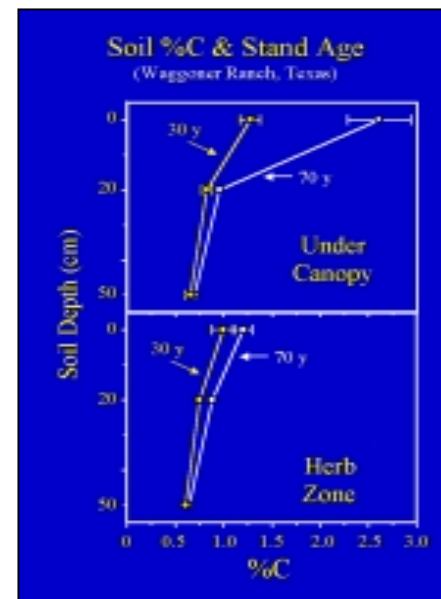
Commercial chile cultivation



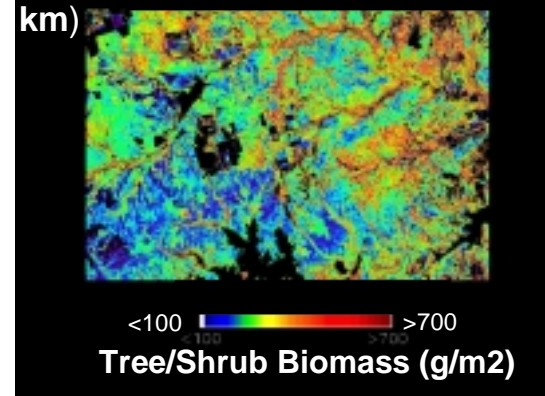
# Example Project: Shrub Encroachment in the S.W. U.S.

P.I. Carol Wessman, University of Colorado

- Brush management is critical to sustainable livestock management in many semi-arid rangelands. The balance between grass and shrubs is regulated by complex interactions between climate, soils, herbivory and land use.
- Changing fire and grazing practices can dramatically alter ecosystem structure (woody plant encroachment) and function (sequestration or liberation of C and N).
- Replacement of C4 grasses by C3 shrubs modifies soils and microclimate:
  - C and N flux from soils increases
  - C and N pool sizes in plants and soils increases
- Remote sensing of vegetation structure coupled with ecosystem simulation models can track biogeochemical dynamics under changing land use and climate.
- Regional accounting of these changes will aid planning/ assessment efforts of landowners and local, state and federal management agencies.



North Texas Savanna (~3500 sq km)



# Hierarchical Investigation of Socioeconomic Drivers of Decadal Scale Land-Cover changes in the Upper Midwest

P.I. Daniel Brown, Michigan State University

Develop a model that projects spatial patterns of land use given socio-economic scenarios in Upper Midwest, North America.

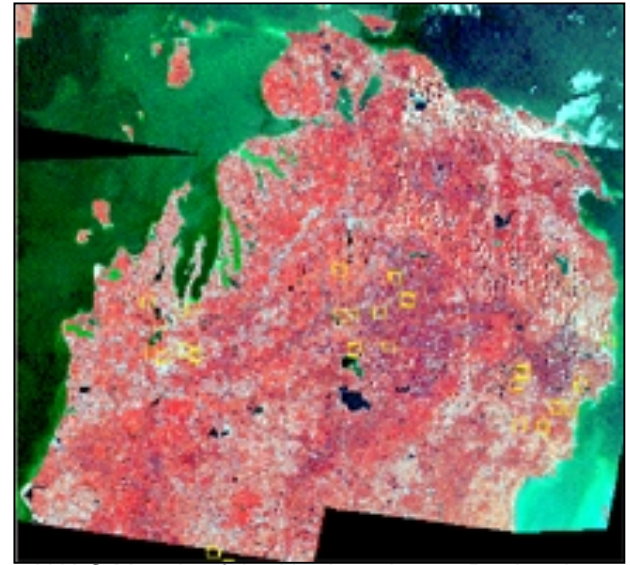
Using Landsat MSS, air photos and plat maps attribute confidence limits to estimates of forest fragmentation from North American Landscape Characterization (NALC) data. Link to census data for artificial neural network analysis

Results indicate that land cover changes in Upper Midwest are attributable to: agricultural abandonment, urban expansion, urban-rural migration, recreation and tourism development.

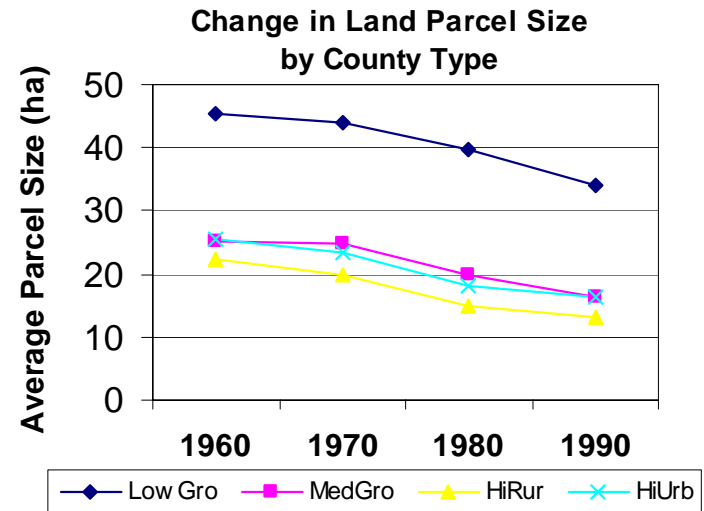
## Projected Applications:

- Inclusion of agricultural changes in predictive models of carbon sequestration for Upper Midwest region.

- Provides land use change information for USGCRP National Assessment of system response to climate change



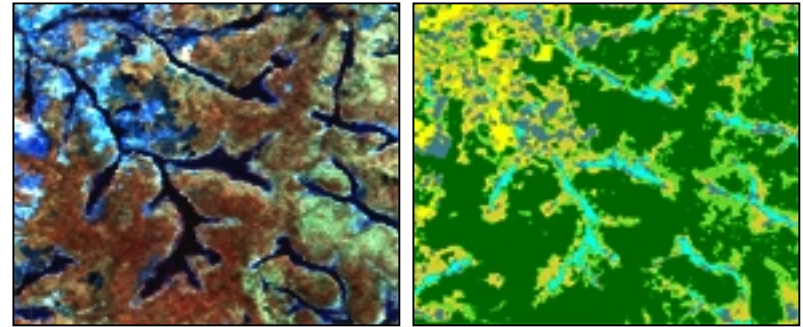
NALC Mosaic of the Northern Lower Peninsula of Michigan 1991



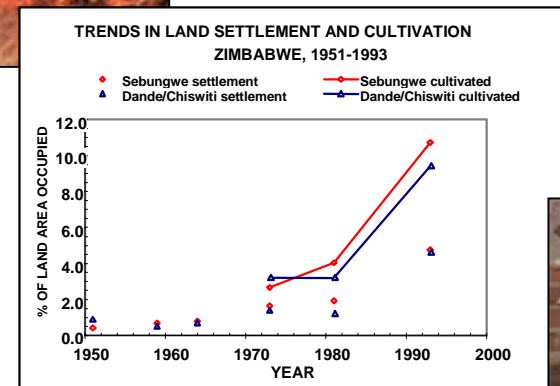
# Coupling Land Cover/Land Use Change and Ecological Processes in Southern Central Africa's Miombo Woodlands

P.I. Paul Desanker, GECP University of Virginia

- To model land cover changes in Miombo ecosystems by an integrated analysis of remotely sensed data, field measurements, and socio-economic drivers.
- Harmonize national products of land cover/land use Landsat TM, field maps and aerial photos into a regional map.
- Apply hierarchical levels from individual household to global scale drivers to land use model.
- Landuse and land cover change varies among nations and is influenced by socio-economic variables such as war, disease, infestation, migration and shifts between subsistence and cash-crop agriculture.
- IPCC non-Annex 1 countries, national policy management
- Regional scale forestry integrated assessment and land use
- Domestic land and trade control policies



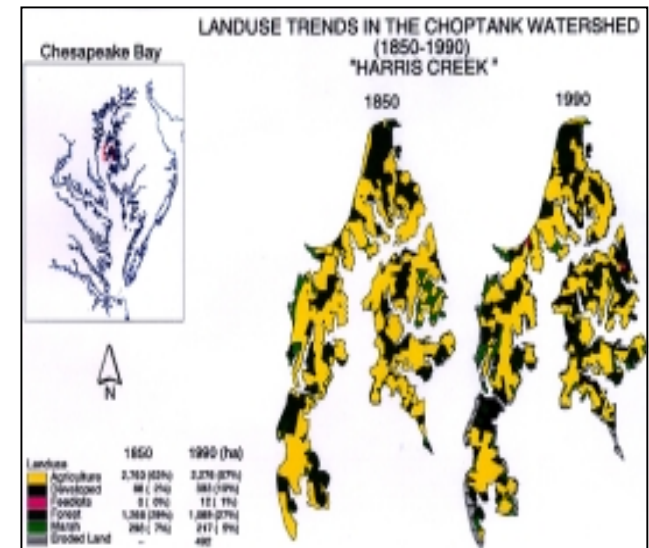
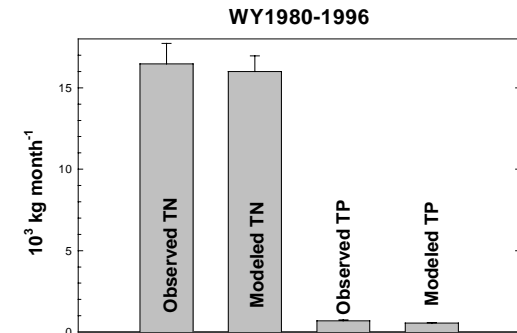
Landsat TM False color composite of Miombo Landscape showing Dambos and Burn Scars on left, classified image on right woodland, grassland, water, scars, cultivated/bare



# Land Use Change and N and P export on the Coastal Plain of the Chesapeake Bay

P.I. T. R. Fisher, University of Maryland

- Substitution of agriculture for forest leads to enhanced export of N and P on the Delmarva coastal plain, enhancing eutrophication of Chesapeake Bay.
- Hydrochemical modeling of current conditions captures this effect with 15-30% errors on an annual basis, <10% errors at decadal time scales.
- Historical maps, aerial photographs, and Landsat data are used to reconstruct land use patterns 1847-2000.
- Initial 1847 - 1990 comparison: losses in forest and agriculture, increases in urban areas and feedlots.
- Adjust model for population changes, atmospheric N deposition, and fertilizer applications for hindcasting to 1850 and forecasting for future management scenarios.
- 2 test catchments: Choptank and Chester on Delmarva used for spatial extrapolation to larger coastal plain area.

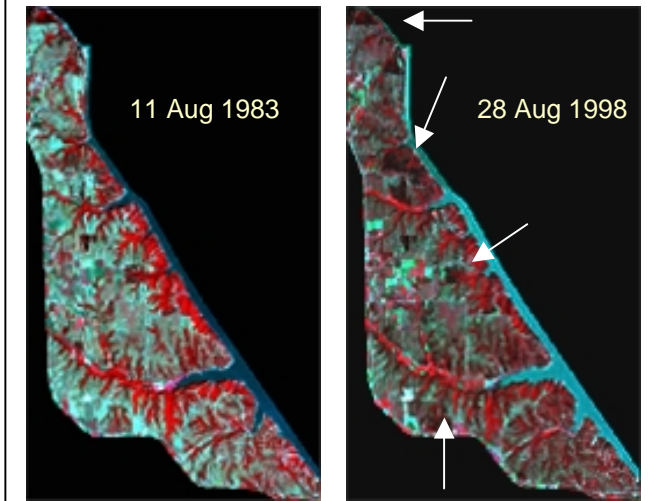


# Land Cover Change in the Great Plains: Predicting the Impact of Regional Forest Expansion on Biogeochemical Processes

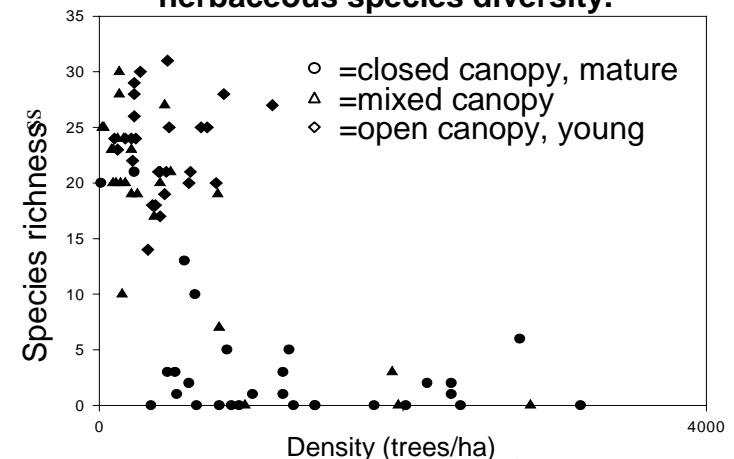
P.I. Loretta Johnson, Kansas State University

- Assess change in forest cover in the Great Plains, quantify the effects of this change on biogeochemical processes and biodiversity, and link land cover change and biogeochemistry in a predictive ecosystem model
- Identify land cover change using Landsat TM and historic aerial photography, collect in-situ biogeochemical data, link in the General Ecosystem Model (MBL-GEM)
- Forest expansion decreases N availability in early spring but by midsummer, N availability in forest and prairie are equal.
- Litter decomposition is slower in forests due to litter chemistry differences.
- Forest expansion reduces plant species diversity.
- Cedar forest area is correlated to population growth at a regional scale.
- Identification of national sources and sinks of carbon – program element of USGCRP
- Accepted ARD activity; Increasing sinks of carbon = reduction of emissions according to Kyoto protocol

Landsat TM images, from 1983 and 98  
arrows indicate increase in cedar



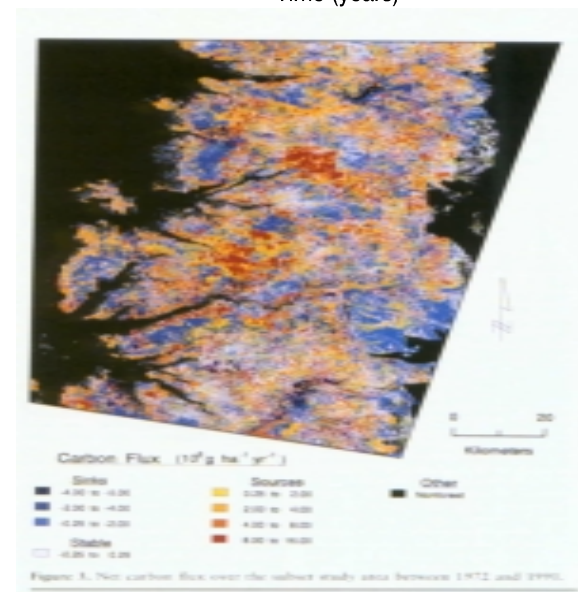
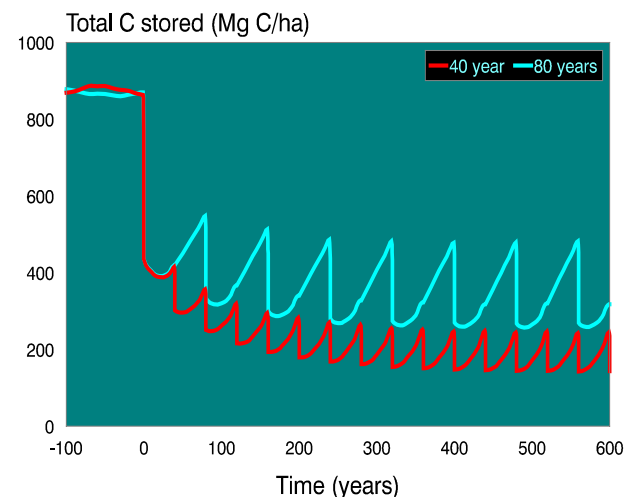
Forest expansion reduces  
herbaceous species diversity.



# Monitoring Carbon in the Pacific Northwest and its Economic Implications

P.I. Mark Harmon, Oregon State University

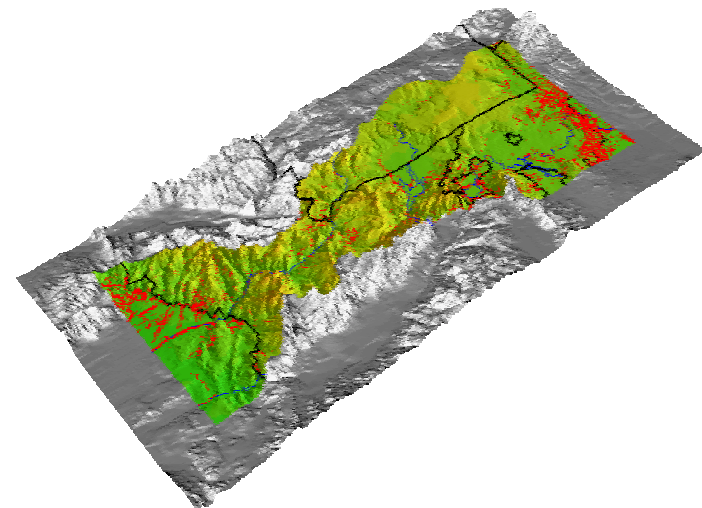
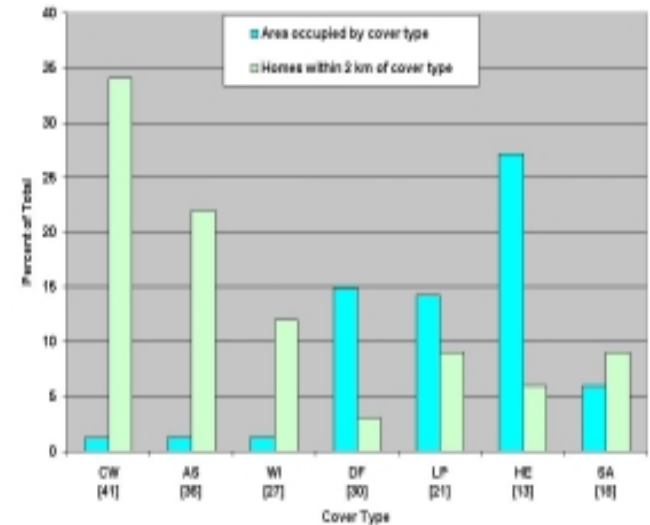
- Quantifying Carbon storage as a function of forest management and age
- A regional project to model carbon under different management practices - using remote sensing, harvest data, stand and regional modeling
- After three decades of management, PNW forests are a net source of carbon
- Carbon storage is sensitive to management - rotation length, harvest method, thinning, planting
- Current assessment of ownership and economics



# Interactions between Biodiversity and Socioeconomics in the Greater Yellowstone Ecosystem

P.I. Andy Hansen, Montana State University

- Quantify changes in biophysical gradients, biodiversity, and land use and socioeconomic factors across the GYE from 1972-1996 and determine interactions. Landsat data, aerial photography, field data along transects, county records
- Native species abundance and richness centered at localized hot spots (< 3% in YNP) - land use is concentrated in the same areas - home density increase associated with reproductive decline - intense land use reduces native population viability.
- Assess current and future risk of ecological hot spots. Develop a land use/biodiversity monitoring system.
- Communicate with stakeholders - conservation planners.

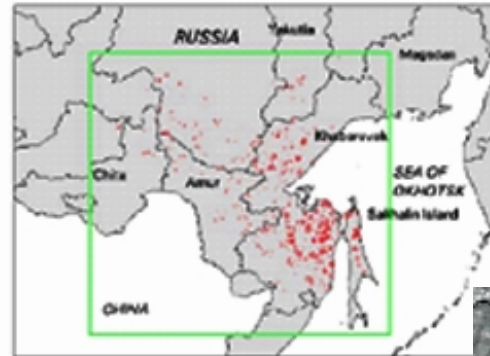


# Effects of the Development and Disturbance on Boreal Forest Cover and Carbon Fluxes in Southern Siberia

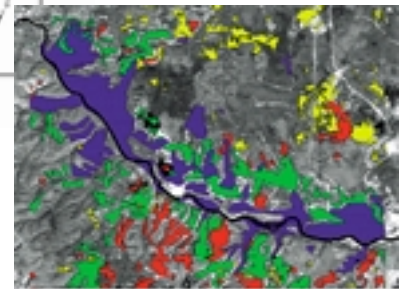
## P.I. Eric Kasischke, ERIM International

- To understand the role of human disturbance on patterns of carbon storage and assessment along the Baikal-Amur Mainline (BAM) Railroad.
- Create a baseline fire location map 1980-1990 using AVHRR to estimate carbon losses.
- Use Landsat to create maps of landuse change in selected areas along the BAM.
- Develop model of forest regrowth and combine with satellite imagery to estimate carbon fluxes along BAM.
- Large area coverage (Landsat) and high spatial resolution sensors (DISP) can be used together for effective monitoring of forest change
- Addresses IPCC goal to better understand disturbance influence on regional carbon fluxes

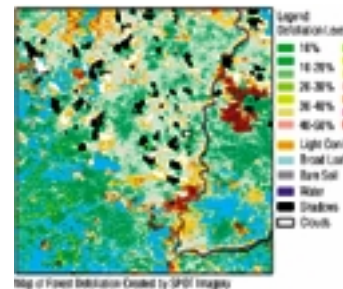
1998 Sever Fires mapped from AVHRR



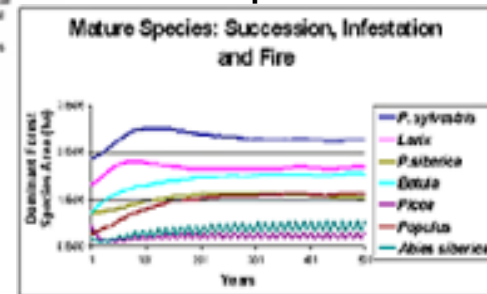
Deforested Areas near the Chuna River 1965-1990 from DISP and Landsat



Defoliation in the Biryusa River Basin from Siberian Silkworm 1994-1996 from SPOT Imagery



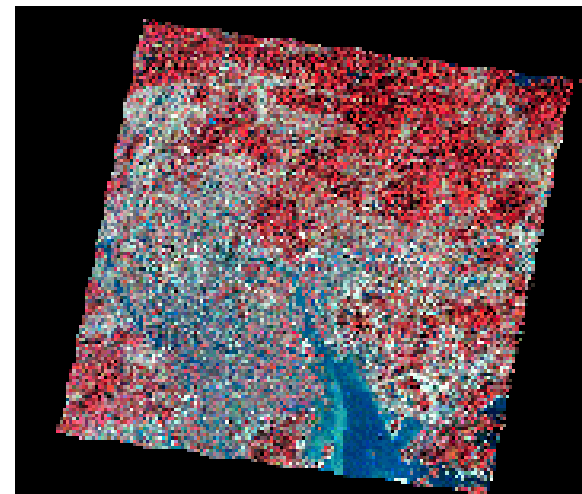
Model output



# **Modeling and Forecasting Effects of Land-Use Change in China based on Socioeconomic Drivers**

**P.I. Robert Kaufmann, Boston University**

- **Quantify land conversion rates and the socioeconomic drivers of land-use change in the Pearl River Delta of Guangdong Province, China**
- **Model land use change under various scenarios of economic development**
- **Estimate the corresponding changes in the biophysical and biogeochemical environment**
- **Use Landsat images to analyze land-use changes from 1973 to 1996.**
- **Build a statistical model that identifies and quantifies the effects of socioeconomic variables on land conversion**
- **The amount of urban land in the Pearl River Delta increased 300% between 1988 and 1996. Most new urban land is converted from agriculture.**
- **Projected implications**
  - **World grain markets/trade agreements**
  - **Domestic energy use and trade reform**
  - **Addresses section of IPCC future needs suggestions**



The Pearl River Delta River Region of Guangdong Province in Southern China

# The Role of Land-Cover Change in High Latitude Ecosystems: Implications for the Global Carbon Cycle

P.I. David McGuire, University of Alaska, Fairbanks

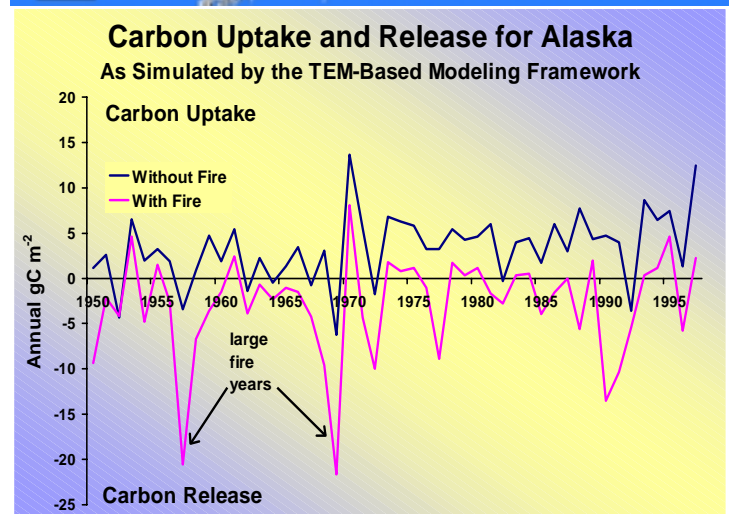
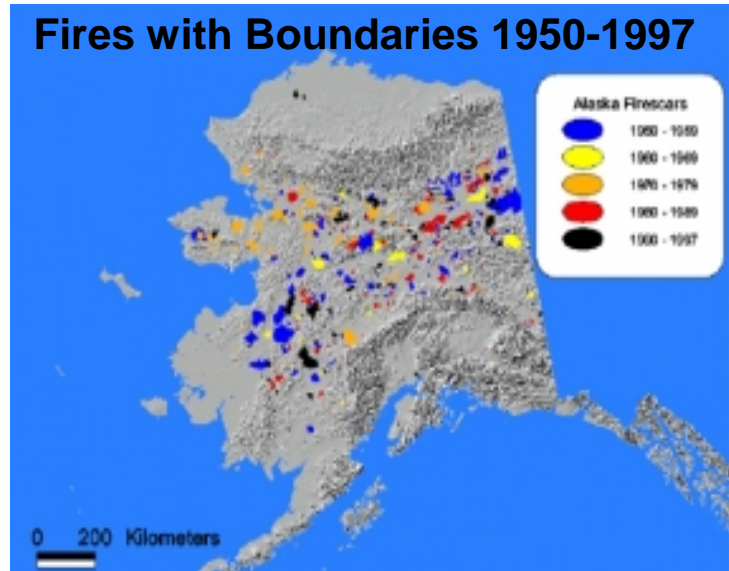
- Semi-automated methodology that uses Landsat and AVHRR data to estimate historical decadal scale land-cover change in high latitude ecosystems. Methodology is capable of being adjusted to use Landsat 7 and MODIS scenes to estimate interannual changes in land-cover for high latitude regions .

- Modeling framework based on the Terrestrial Ecosystem Model (TEM) that simulates terrestrial carbon storage responses to historical fire and climate in Alaska.

- Implementation:

- Supports CCSI program element regarding disturbance effects to ecosystem function.
- Supports the National Assessment through evaluation of the vulnerability of Alaska to climate variability and change.

(For more info see <http://alces.sel.uaf.edu>)



# Land-Use and Land Cover Change in Sonora, Mexico: trajectories of agricultural intensification in the Yaqui Valley Northwestern Mexico

P.I. Pamela Matson, University of California, Berkeley

- To evaluate the causes and on- and off-site consequences of 30 years of agricultural intensification - increased yields
- Regional effects of nitrogen application
- Responses - institutional changes in factor and product markets, changes in cropping patterns, changes in farmer practices
- Intensification with expansion
- Projection of impacts of planned reforms
  - Domestic agricultural policy reform (Procampo)
  - Regional trade agreement (NAFTA)
  - Elimination of federal subsidies on water
  - Constitutional change in land tenure laws

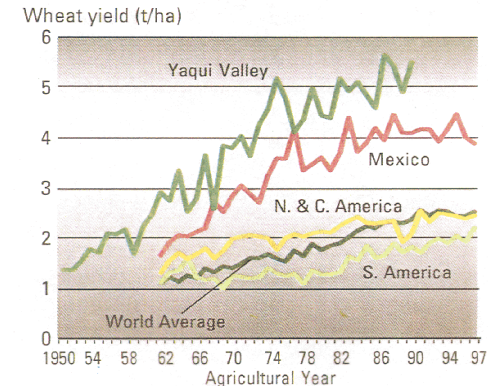
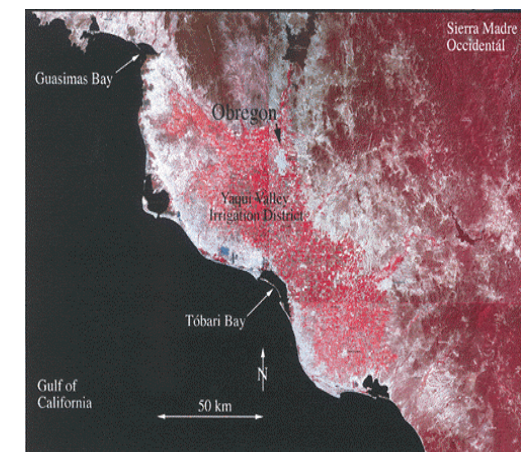


Figure 3. Comparison of world wheat yields to the Yaqui Valley.

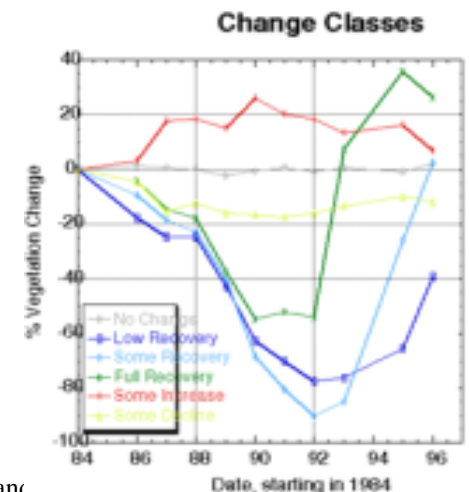
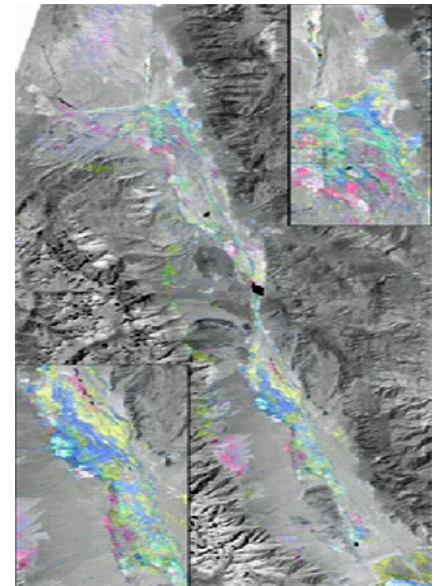
Source: FAO Production Yearbook, CIMMYT.



# Example Project - The Dynamics of a Semi-Arid Region in Response to Climate and Water-Use Policy

P.I. John Mustard, Brown University

- Study of the characteristics and magnitude of change of both natural and managed ecosystems of Owens Valley over 15 years in response to natural and socially-driven forces
- Tracking vegetation response to the combination of drought, water draw-down, and recovery from drought using detailed field survey and remote sensing to scale local measurements to the regional scale
- Large changes observed, management of resources tied to ecological health
- Effect of prior land use on vegetation response - pre 1900, 1926 survey, aerial photography 1944, 1969, 1983
- Preliminary interactions with LA water managers and Inyo County officials



# Deforestation and Degradation in Southern Central African Savannas

P.I. Stephen D. Prince, University of Maryland

- Socio-economic drivers and biophysical factors employed to identify land degradation processes in Southern Africa.

- Radar to measure biomass. Visible, near infrared and thermal remote sensing to monitor primary production.

- Soil moisture and runoff modeled with surface water and energy balance models driven with remotely sensed data.

- Biophysical, socio-economic and cultural variables combined to identify leading indicators of environmental degradation.

- Rain use efficiency normalizes effect of rainfall on regional NPP

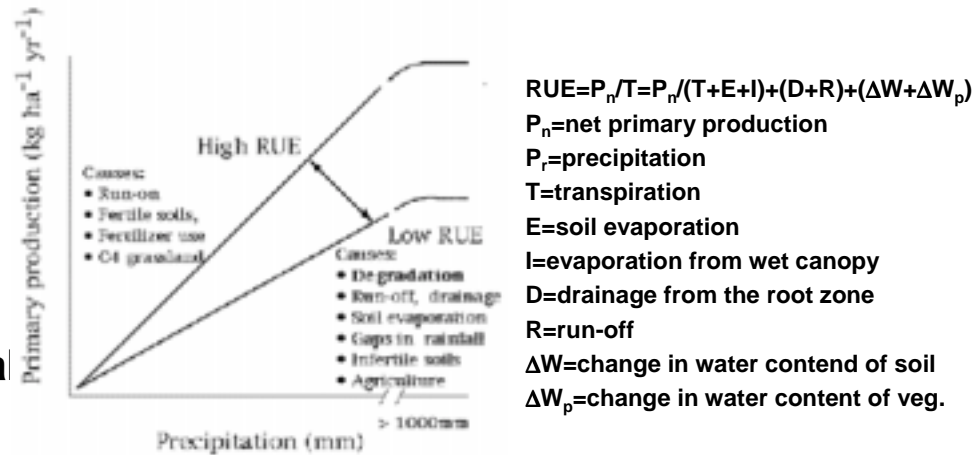
- Soil moisture stressor is a continuous variable rather than an on/off switch

- Regional integrated assessment.

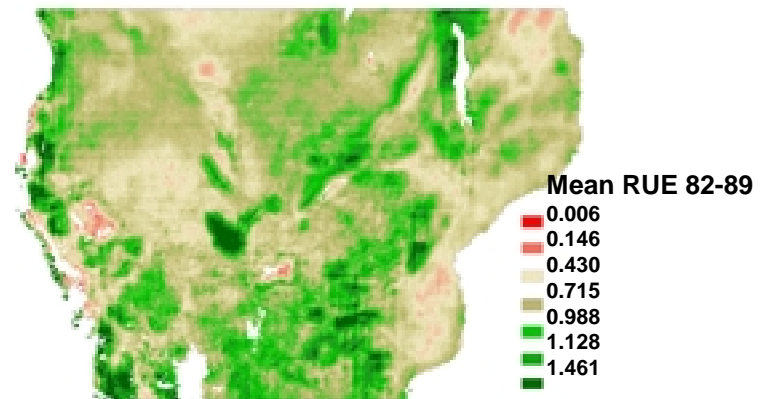
- Domestic water policy and agricultural reform.

- USGCRP overall goal to understand and predict human-induced changes to environmental systems

Rain Use Efficiency (RUE)



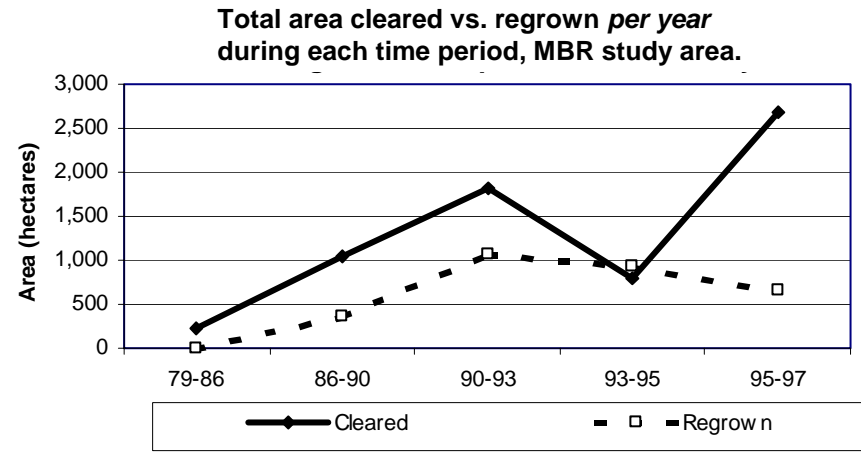
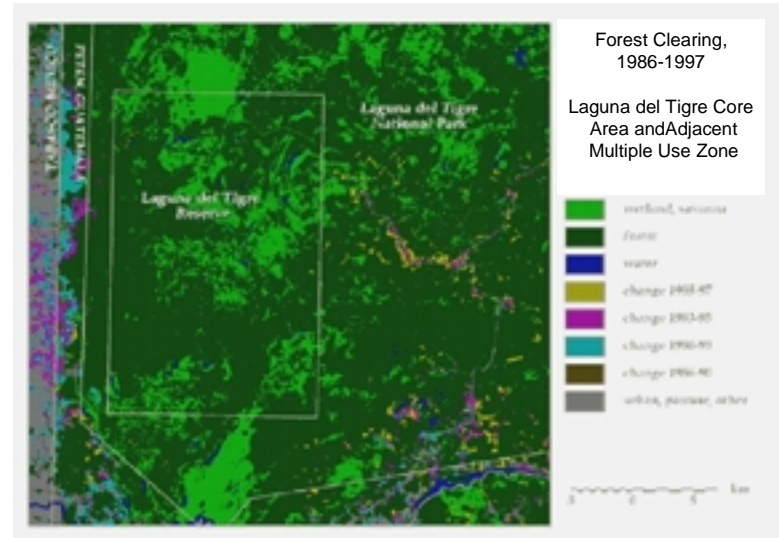
Mean RUE



# Time-series Forest Change, Land Cover/Land Use Conversion and Socio-economic Driving Forces in the Petén, Guatemala

## P.I. Steven A. Sader, University of Maine, Orono

- Develop a land-cover/land-use change database of the Maya Biosphere Reserve (MBR) for 1974-97.
- Quantify forest clearing and regrowth rates by time period.
- Determine socio-economic factors that influence land-use change decisions.
- Satellite image change detection techniques were applied to time-series Landsat MSS and TM imagery to develop data on forest clearing rates and trends.
- Clearing to regrowth area ratios and patch characteristics varied among study sites for the different time periods.
- Agricultural reforms; i.e. fallow periods, mono-cropping, pasture development, harvest of non-timber forest products.
- Changes in domestic settlement incentives following assessment of change rates.
- Biosphere level monitoring and periodic updates are instrumental in NGO/donor conservation management strategy and policy development.

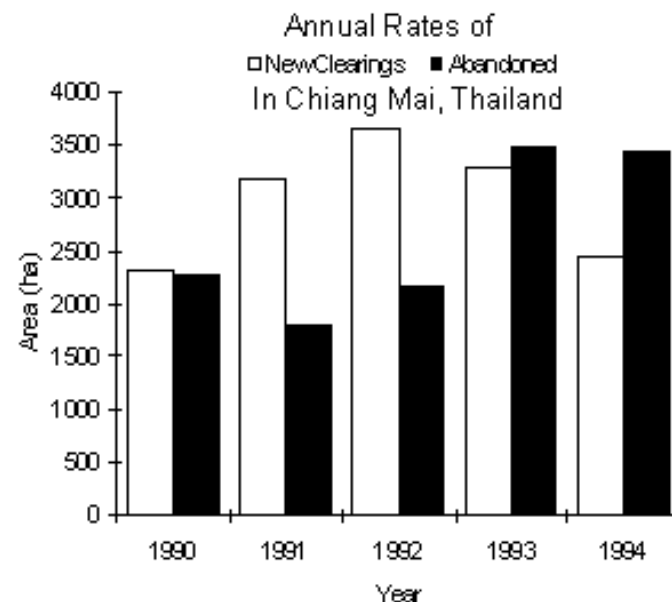
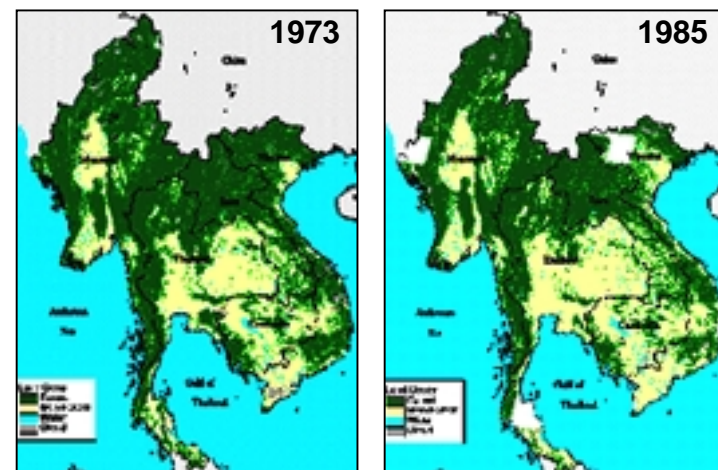


# Case Studies & Diagnostic Models of the Inter-annual Dynamics of Deforestation in Southeast Asia

P.I. David Skole, Michigan State University

- Determine inter-annual deforestation dynamics in Southeast Asia; building a regional perspective from case studies
- Develop diagnostic models of the deforestation process to quantify the significant socio-economic drivers
- Use Landsat imagery for land cover/land use change detection at four study sites (located in Thailand, Indonesia, Malaysia, Philippines)
- Collect field and socio-economic data for a two-date probability model for each site
- Analyze and synthesize data, develop models
- Area of deforestation in Northern Thailand increased by 36% from 1980-90; decreased in 90s
- Annual deforestation rates are highly variable
- Agricultural expansion is the main driver of deforestation in Chiang Mai, Thailand
- Domestic agricultural/logging reform
- Local economic/employment
- Regional carbon emissions forecast-Kyoto protocol

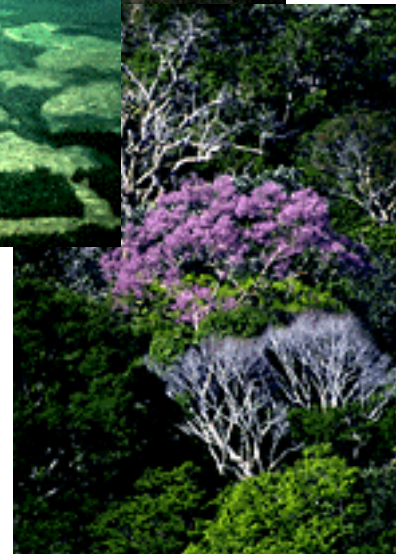
Regional forest cover in Southeast Asia



# **Anthropogenic landscape changes and the dynamics of Amazonian Forest Biomass**

**P.I. William Laurance, INPA and Smithsonian Institution**

- To develop a predictive model of carbon stock and their dynamics for the Amazonian forest
- Collaborative research effort between Brazil's National Institute for Amazonian Research (INPA) and the Museum of Natural History of the Smithsonian.
- Use Landsat TM images of central Amazonia to classify landscape
- Combination of field studies and computer modeling to estimate biomass of above ground biomass
- Land-use history after forest clearing has deterministic effect on forest regeneration trajectory
- Herbivores have strong negative impact on regeneration of degraded lands
- Logging strategies in second growth forests enhance survival of commercially important trees
- Provides baseline data for developing carbon trading with Annex 1 countries as suggested in Kyoto protocol



# Human and Physical Dimensions of Land Use/Cover Change in Amazonia: Forest Regeneration and Landscape Structure

P.I. Emilio Moran, University of Indiana, Bloomington

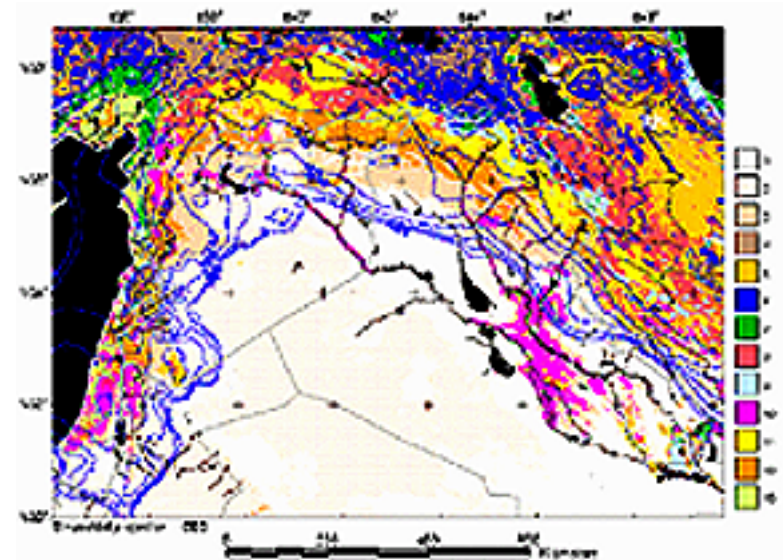
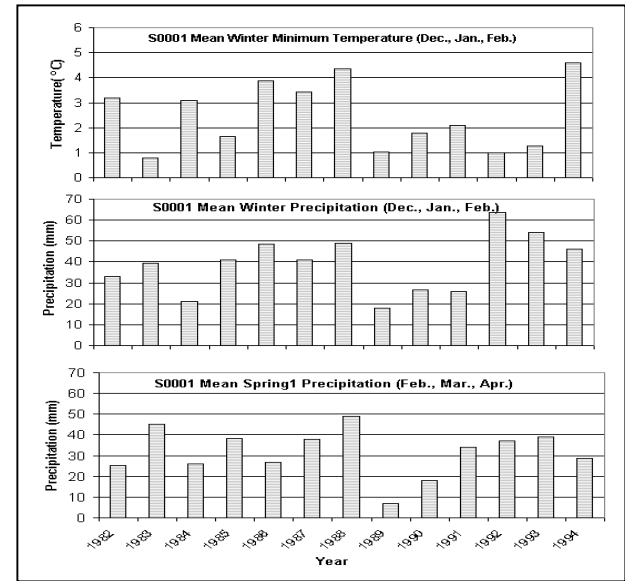
- Quantify ecological and socioeconomic drivers of land cover change over past 25 years in seven regions of the Eastern Amazon
- Classification of multi-temporal LandsatTM scenes to understand rates of secondary vegetation growth
- Field data collection including soil analysis, forest structure and composition
- Demographic data, population density, agricultural practices
- Land tenure
- Agricultural reform
- Establish non-annex 1 countries infrastructure for carbon flux monitoring



# Climate Change and Human Response in the Semi Arid Near East

## P.I. Ron Smith, Yale University

- Quantify aspects of regional environmental change on the mesoscale (5-500km) related to interannual climate variation, alterations in population density and agricultural strategies in the Middle East.
- Using remote sensing (AVHRR and Landsat), climate data, and field work with local experts, assess the drivers of regional environmental change and model land cover changes.
- Supplemental irrigation in the spring creates problems in the satellite landcover classification, therefore summer crops will be focus
- Winter precipitation (Dec, Jan, Feb) and minimum temperatures in the spring (Feb, Mar, April) are strong influences on specific vegetation zones in different months.
- Potential polciy impacts:
  - farming and grazing on marginal areas,
  - cropping efficiency
  - Irrigation; water consumption,
  - land restoration,
  - population growth and migration

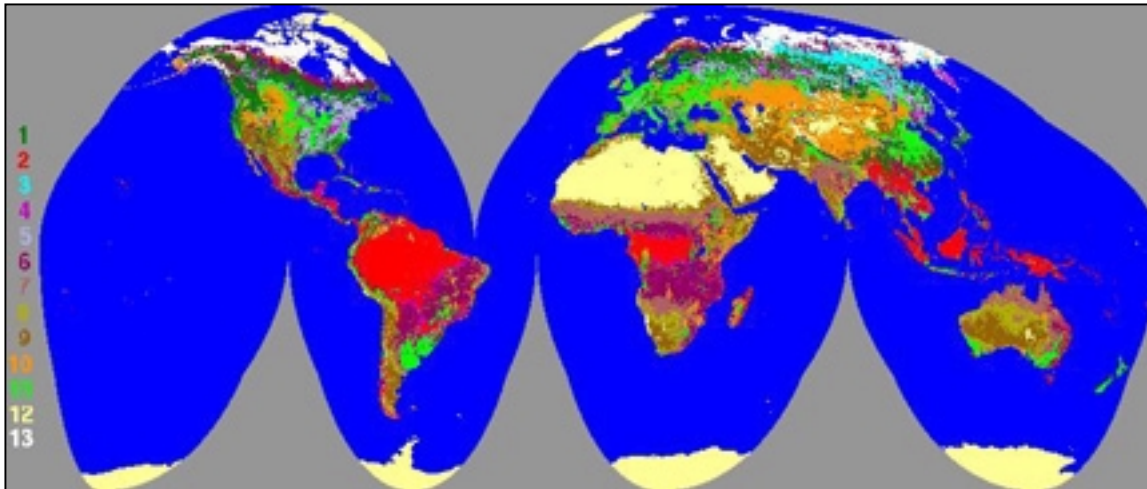


SWAP13 Multitemporal Unsupervised Classification of 1km Composite NDVI 10/1992-9/1993

# CHARACTERIZING LAND COVER HETEROGENEITY AND LAND COVER CHANGE FROM MULTISENSOR SATELLITE DATA

**P.I. Ruth Defries, University of Maryland**

- Improve characterization of land surface in regional and global Earth system models  
spatial: land cover heterogeneity temporal: interannual variability and land use change
- Characterization of global land cover from satellite data at 1km resolution with continuous fields of vegetation properties and by discrete cover type
- Initial efforts to integrate continuous fields of vegetation properties into earth system models
- Addresses national estimate needs of forest gain/loss as suggested by IPCC and USGCRP initiative



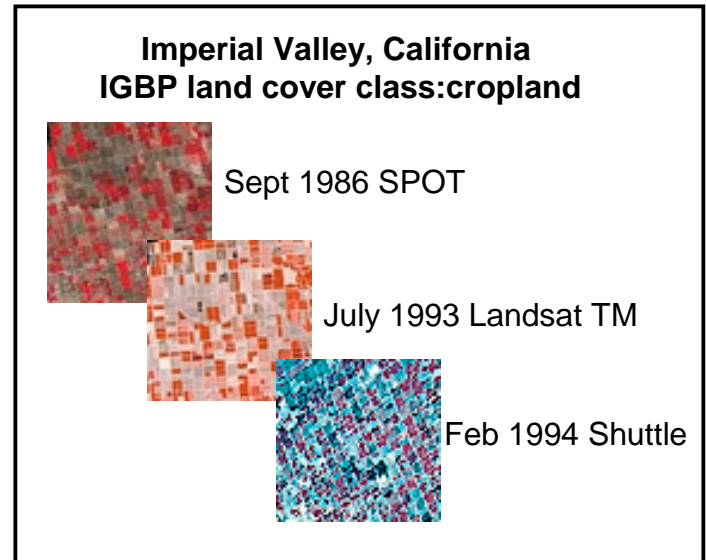
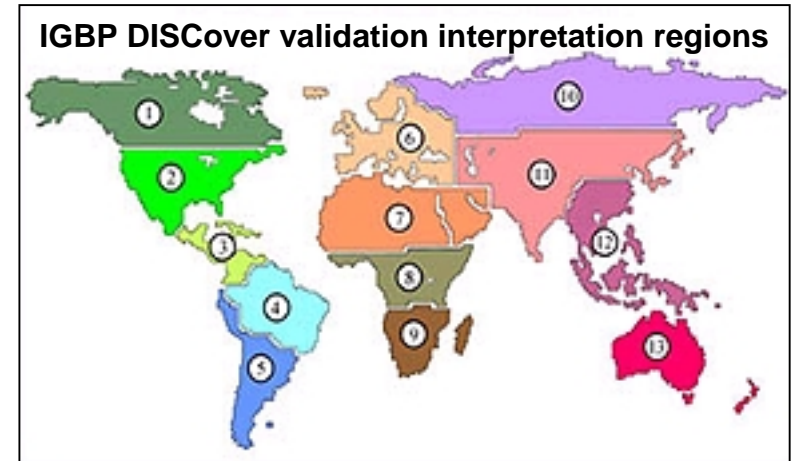
## **A Key to the Related Map:**

1. Evergreen needleleaf forest
2. Evergreen broadleaf forest
3. Deciduous needleleaf forest
4. Deciduous broadleaf forest
5. Mixed forest
6. Woodlands
7. Wooded grasslands/shrublands
8. Closed bushlands or shrublands
9. Open shrublands
10. Grasses
11. Croplands
12. Bare
13. Mosses and lichens

# Accuracy Assessments of the IGBP Fast-Track 1 Km Land Cover Data Sets

P.I. Jack Estes

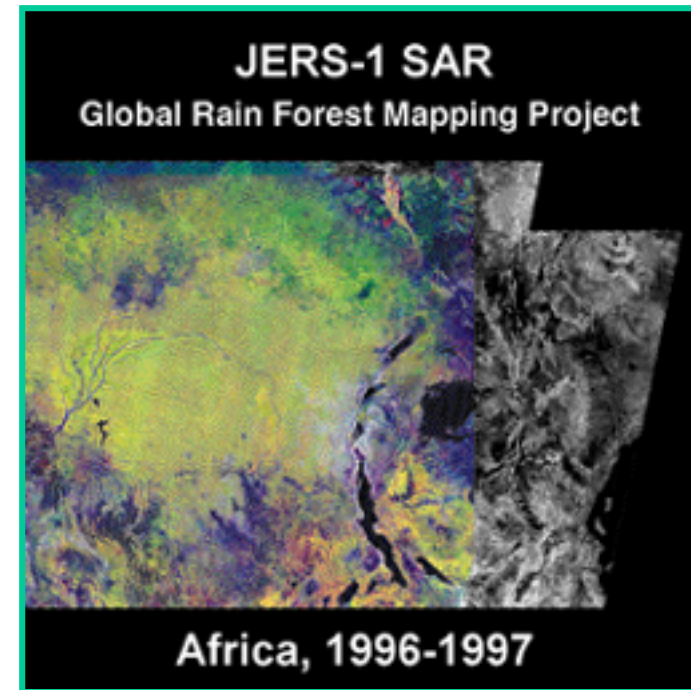
- Assess the accuracy of the IGBP Global 1-km Land Cover Data Set (v.1.0, "Fast Track" or IGBP-DIScover) which was prepared from 1-km AVHRR composited NDVI data.
- Approximately 425 Landsat, SPOT, and photos taken from the Space Shuttle used in conjunction with auxiliary texts and maps will be used to validate the IGBP land cover classification.
- 17 land cover classes ranging from natural vegetation to developed and non-vegetated classes.
- Segmented global land surface into separate validation regions based on the START framework- which was developed to coordinate scientific research within regional origins of global environmental change.
- Addresses mandate of the IGBP-DIS to provide accurate, fine-resolution land cover data for use by IGBP Core Projects.



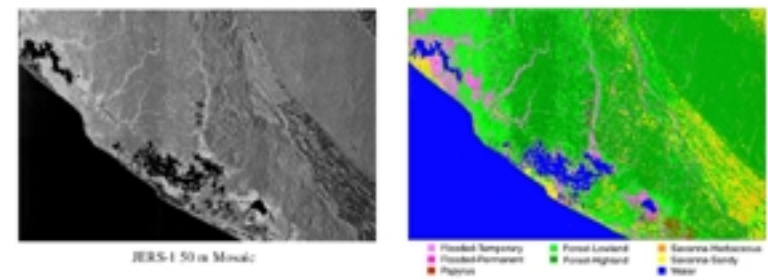
# **Study of Land-Use and Deforestation In Central African Tropical Forest Using High Resolution SAR Satellite Imagery**

**P.I. Sasan Saatchi, Jet Propulsion Laboratory**

- Use high resolution satellite imagery to map areas of forest clearing and general land cover types for the entire Central African tropical region.
- A combination of radar backscatter and texture analysis of images acquired by the JERS-1 SAR instrument are used to classify land cover into five categories; forest, non forest, savanna, flooded forest and open water.
- Technique developed for mosaicking images minimizes error propagation
- High resolution imagery and large scale mosaic allow for enhanced visualization at both fine and coarse scale
- Biodiversity assessment, identification of unique places
- Domestic/regional agricultural reform
- Infrastructure for data collection of for non-annex 1 countries under Kyoto Protocol



JERS1 mosaic @ 50 m resolution validation site, Gamba, Gabon



S. Saatchi & E. Podest (NASA/JPL)

# Summary of Achievements

- **Process Case Studies**
  - 22 regional process studies combining satellite data, physical and social science - understanding causes and impacts of land cover change
- **Science Data Sets**
  - global land cover (1km) mapping and validation (AVHRR)
  - regional deforestation maps tropic (Landsat)
  - regional microwave land cover data sets for tropical regions (JERS)
  - CD's of regional land cover data sets - southeast Asia, southern Africa
- **Technique Development**
  - land cover classification and characterization / change detection
  - fusion of social and physical science / LCLUC modeling
- **Model intercomparison**
  - VEMAP contribution to the national assessment
- **Outreach Initiatives**
  - World Fire Monitoring Web Site (OSTP)
  - Global % Tree Cover Poster (OSTP)
  - LCLUC WEB Site

# **Program Linkages**

**(LCLUC initially envisioned as an ESE cross cutting theme)**

- **Internal Program Linkages**
  - **Ecology / Biogeochemistry - Disturbance / LBA**
  - **Applications Program**
  - **NASA / NGO Biodiversity**
  - **Contribution to Regional Field Programs - LBA / SAFARI-2000**
  - **Validation Program**
    - Global 1km Land Cover Validation
    - EOS Validation - land cover, % tree cover, fire,
  - **Data Systems**
    - ESIPS e.g. Land Cover (UMd) / Rainforest Report Card (MSU)
- **External Program Linkages**
  - **National Assessment**
  - **USGCRP Carbon Initiative**
  - **USAID - CARPE**
  - **CEOS - GOFC and CEOS -Validation**
  - **IGBP/IHDP LUCC**
  - **GTOS - NPP**

## **USGCRP - New Carbon Cycle Initiative**

- **Land use currently has been given a relatively minor emphasis to date compared to atmosphere and ocean science**
- **Proposed Research Areas concerned with Land Use**
  - **Effect of past and current land use changes on carbon storage**
  - **Inventory and long term monitoring of carbon stocks**
  - **Quantify spatial and temporal distribution of sources and sinks on a regional scale and understand processes that control distribution**
  - **Understand land management factors that regulate net sequestration of anthropogenic CO<sub>2</sub>**
  - **Lifetime, sustainability and variability of sources and sinks of CO<sub>2</sub>**
- **Agency roles and specific contributions in the area of land use research have yet to be determined - e.g. USDA, USFS, USGS, NASA, NSF-Human Dimensions**

# NASA Satellite Missions for LCLUC Science

- **Systematic Measurements**

- MODIS ( land cover, land cover change, fire and burn scars)
- Landsat 7 ( quantifying land cover extent and rates of change)
- Ikonos - commercial data buy ( land use characterization, validation)
- Landsat Follow-On ( monitoring land cover change)
- NPP-VIIRS( monitoring land cover, land characterization, fire)

- **Experimental Missions**

- EO1 ( hyperspectral cover characterization, vegetation composition)
- VCL ( vegetation structure and biomass, carbon studies)
- Vegetation recovery ( vegetation regrowth, carbon studies)
- LightSAR ( vegetation structure, biomass mapping)

## **Current and Future Directions for LCLUC**

- **Satellite based process studies on causes and impacts of land cover change - blending physical and social science - developing predictive capabilities.**
- **Land cover - land use component of the Carbon Cycle - contributing to the emerging USGCRP Carbon initiative**
  - **CEOS GOFC - operational data for LCLUC Carbon research**
  - **LCLUC disturbance initiative**
  - **Integrating satellite based LCLUC data into regional and global models**
  - **Incorporating satellite data in science assessments (national /regional)**
- **Developing new methods and techniques for satellite land cover characterization using existing systems AVHRR/ Landsat/ JERS.**
- **Preparation for new land cover related satellite missions Terra / EO1 / VCL / Lightsar / Landsat follow-on / Transition of NPP into NPOESS.**
- **Highlighting and demonstrating policy relevance of LCLUC science re.- biogeochemistry - carbon cycle, land atmosphere interactions, water and food supply, human health, biodiversity.**
- **Science underpinning to sustainability questions.**

# Global Fire Monitoring Web Site

Chris Justice, University of Virginia / David Herring, Goddard Space Flight Center



## GLOBAL FIRE MONITORING

SCIENCE • SYSTEMS • REGIONS • RESEARCH • EOS • INITIATIVES • LINKS

Roughly 175 million acres of forest and grassland are burned each year world-wide.<sup>1</sup>



[state of the science](#)  
[fire emissions](#)  
[satellite systems](#)  
[global data products](#)  
[regional examples](#)  
[EOS generation sensors](#)  
[related links](#)  
[list of references](#)  
[bibliography](#)  
[glossary](#) NEW!  
[acronym](#) NEW!


The average surface temperature of the globe has increased over the last 100 years by almost one degree celsius. Increases in greenhouse-gas concentrations appear to be at least partially responsible for the warming trend. Due to large-scale deforestation activities, grassland fires and naturally occurring wildfires around the world, biomass burning is a major source of greenhouse gases and aerosols. While the increase in temperature may seem insignificant, the uncertainty in the emissions from the burning process is a major concern. These emission products impact atmospheric chemistry, cloud properties and the Earth's radiant energy budget (heat and sunlight) in ways that influence climate on a regional and global scale.<sup>2,3</sup>

Fire has always been and continues to be an integral part of land use and culture around the World. Greater emphasis is being placed on obtaining more accurate assessments of emissions from biomass burning. Remote sensing of fires, smoke and even burn scars allows for improved detection of fire characteristics as well as their short and long-term effects on ecosystems.

### New Images



**Fires in Florida**  
Spring 1999 NEW!



**Fires in Canada**  
May 1999 NEW!



**Fires in Mexico**  
May 1999 NEW!



**Fires in Russia**  
May 1999 NEW!

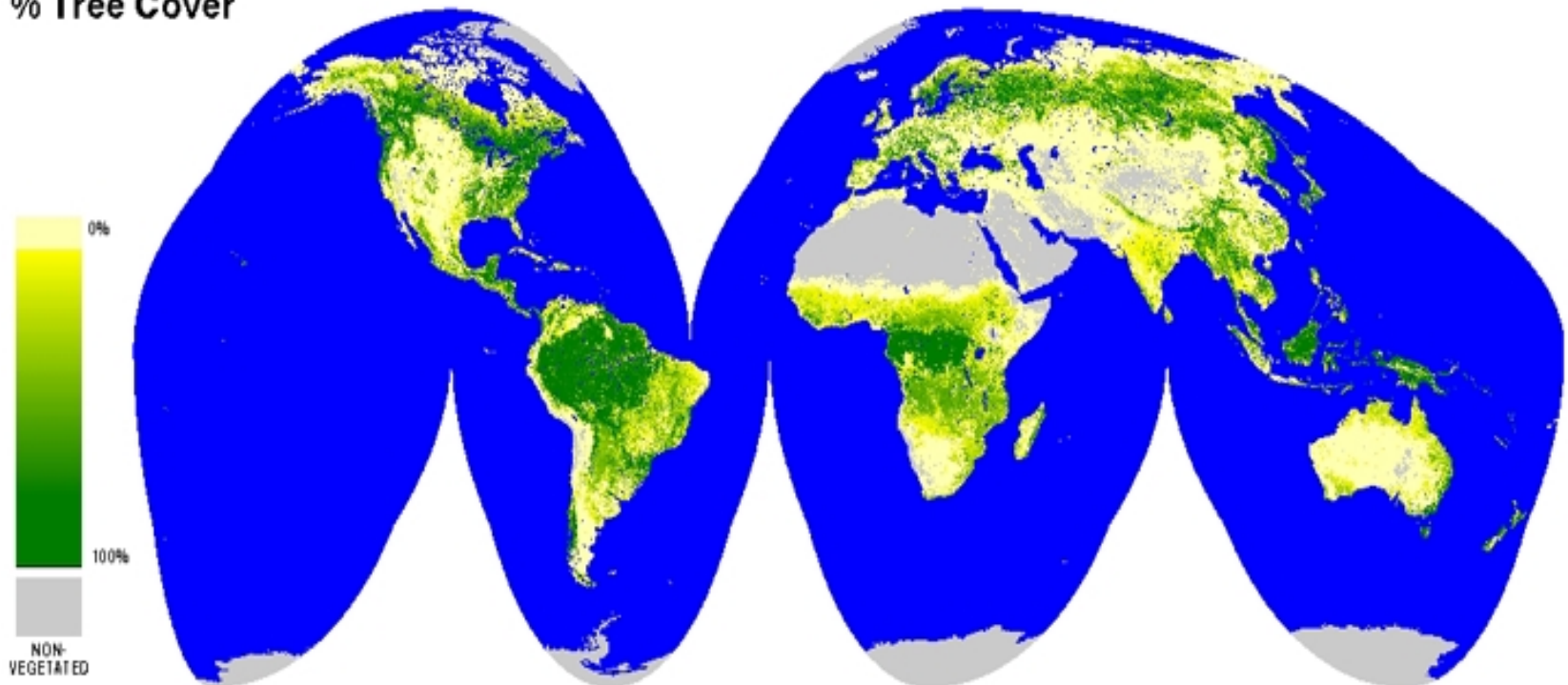


**Global AVHRR  
Vegetation  
Fires**

# Global Percentage Tree Cover Product derived from AVHRR data

John Townshend / Ruth Defries, University of Maryland

% Tree Cover



A prototype data set estimating percent tree cover from 10 to 40 percent based on satellite data acquired by the Advanced Very High Resolution Radiometer in 1992-95. Percent tree cover is likely to be underestimated in areas with significant cloud cover throughout the year. The spatial resolution of 1 km precludes the detection of finer forest fragments. Future satellites with higher spatial resolution will improve detection of forest patches as well as areas undergoing land cover change. Note that this is an equal area map projection and hence tree cover in high latitudes appears less extensive than in conventional maps.